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Embossing

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42.1 General

Embossing is a method by which a web is textured by the use of a pattern roll pressing against a backup roll under controlled conditions. One can emboss both thermoplastic and nonthermoplastic webs by choosing the proper roll arrangement to deform the web.

To emboss thermoplastic materials, the web is deformed by preheating and pressing it with a cooled embossing (pattern) roll to set the pattern and cool the web to retain that pattern.

The degree of preheating to soften the web must be carefully controlled so that no melting or degrading of the web will take place. To make the heat removal process as efficient as possible, no more heat should be applied than is needed to satisfactorily emboss the product.

To emboss a nonthermoplastic web, such as paper, textile, or foil, one must apply pressure that exceeds the elastic limit of the substrate and imparts the pattern. This type of embossing involves the use of male and female rolls, either two rolls with matched patterns made of steel or other metal, or a steel pattern roll that comes in contact with a filled backup roll, which takes a permanent deformation for a given pattern by running the steel embossing roll in contact with the backup roll during a "running in" period. In some cases, special rubber-covered rolls can be used; their behavior eliminates the need for "running in."

42.2 Thermoplastic Webs

Embossing thermoplastic webs is achieved by using an engraved metal roll pressing against a rubber-covered backup roll. The metal roll is cooled with a refrigerated solution to remove heat from the product and to set in the embossed pattern. The backup roll is internally cooled, mainly to increase the life of the rubber covering. The roll may also be cooled externally by a water bath and squeeze roll system, especially if the web is an unsupported thermoplastic film having a tendency to adhere to a hot rubber surface.

Embossing of a web depends on many variables, such as the following:

- Degree of preheating and rheological properties of the product
- Sheet thickness
- Hardness of the rubber backup roll
- Embossing roll pattern and its cooling capacity
- Postemboss cooling

A fine balance exits between the preheating and the removal of heat to set the pattern. Applying the appropriate amount of preheat but insufficient cooling results in the inability to deform the web, which

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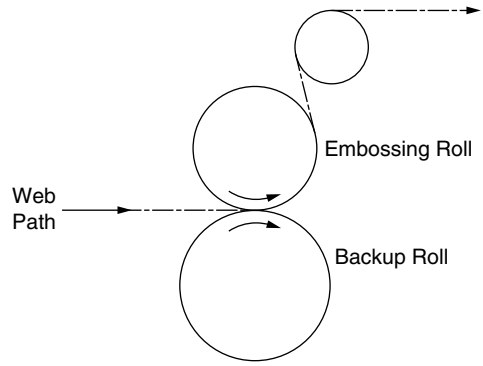

FIGURE 42.1 Vertical embossing unit.

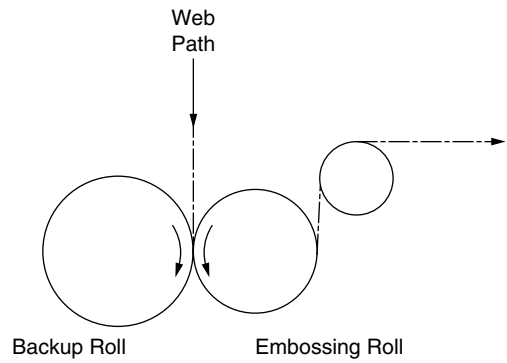

FIGURE 42.2 Horizontal embossing unit.

has not been softened enough. The best embossing system is one that optimizes heat input and removal for a given thickness and speed.

The hardness of the backup roll plays a role in the finished product's texture. If a roll is too hard, a good definition of fine surface patterns might be achieved, however, displacement of material within the product for deep embossings may not be possible. If the roll is too soft, it will allow deep embossings to show through the back of the product, an effect that is objectionable in some applications.

The need to cool the product after it has left the embossing roll is another important factor. Appropriate postcooling facilities, usually cooling rolls, are used to bring the sheet temperature as close to ambient conditions as possible before the product is rewound into a roll. When cooling a thin sheet, the problem of retained heat is minor, because a thin sheet releases heat easily. In heavy sheet embossing, although the surface of the web might feel cool, the heat is retained in the body of the sheet. This heat, if it remains, will cause a loss of embossed grain when the product is later rewound for further processing.

Embossing units can be placed in various geometric positions. They are usually either vertical, where the web path enters in a horizontal manner, as shown in Figure 42.1, or they can be placed in a horizontal fashion, as shown in Figure 42.2. Under special conditions and for certain applications, it might also be advantageous to find them disposed at a particular angle, as shown in Figure 42.3.

The preheated web should enter the embossing nip perpendicular to the line of action of the embossing and backup rolls, to ensure that the web is not prematurely cooled by striking either the embossing roll or the backup roll first. It is acceptable and sometimes desirable, however, that the backup roll be contacted first. Many webs are unstable in their preheated condition and will be easily creased if they enter the nip unsupported. A short arc of contact before the embossing action of the nip allows the web to be flattened. It is also preferable to contact the backup roll first, because the surface temperature of the backup roll is higher than that of the cool embossing roll; thus, the amount of heat removed from

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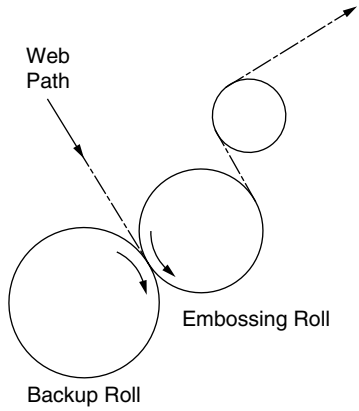

FIGURE 42.3 Embossing unit at an angle.

the preheated web is minimized. Furthermore, the heat is removed from the back side rather than the face that is to be embossed.

42.2.1 Embossing Machines for Thermoplastic Webs

Figure 42.4 shows an embossing machine that incorporates a preheating drum with the addition of a surface radiant heater, an embossing section consisting of a metal embossing roll and a rubber-covered backup roll, and appropriate cooling rolls.

Polyvinyl chloride (PVC) film having a moderate thickness of 0.2 to 0.3 mm (0.008 to 0.012 in.) is unwound from a tension-controlled unwind to assure that it is not stretched during the process. It enters the preheating area by passing over a spreader roll and is applied to the heat drum by use of a lay-on roll. The lay-on roll is a rubber-covered, pneumatically operated roll, whose function is to lay the web onto the heated drum surface, allowing for intimate contact and preheating.

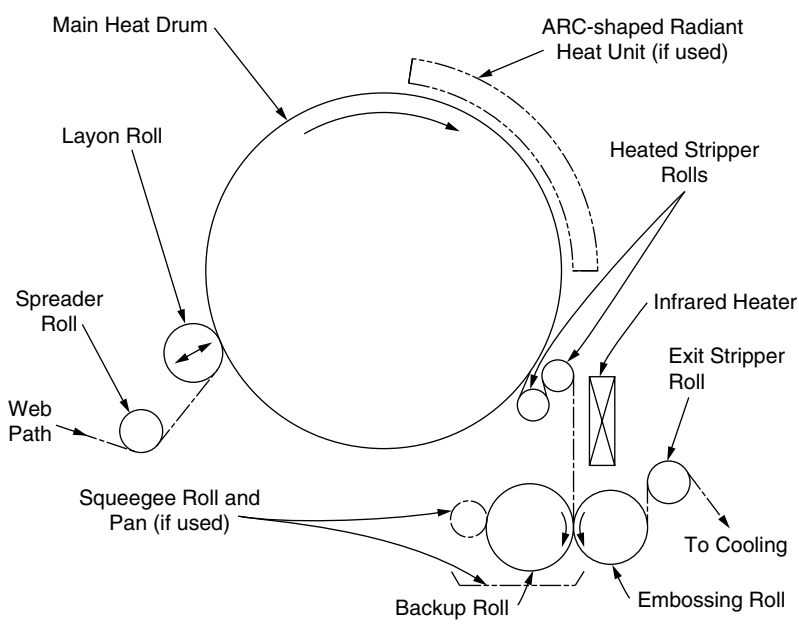

FIGURE 42.4 Embossing machine.

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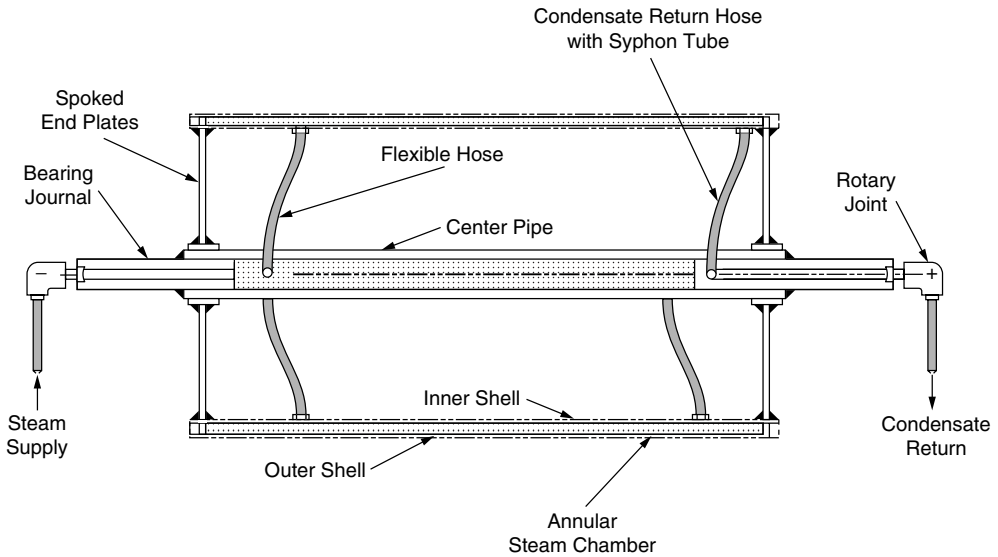

FIGURE 42.5 Steam-heated drum.

The drum is heated by steam or hot oil and is usually 1 to 1.5 m (36 to 60 in.) in diameter. Steam heat is preferred, as it responds to temperature changes more readily than does hot oil. For this thickness of web, the arc-shaped radiant heat unit around the periphery of the drum is not required.

The steam-heated drum has a double-shell construction as shown in Figure 42.5. Saturated steam enters from one end and passes through the center shaft of the drum; then it is fed through passages to the annular section formed by the inner and outer shells of the drum. As the steam fills the annular chamber and performs its work, condensation takes place and is removed through similar passages at the opposite end of the drum by a siphon tube and exits through the shaft opposite the steam inlet. Both the steam and the condensate enter and leave the drum through rotary joints furnished with bronze hoses to withstand the temperature of the steam. The rotary joints are pipe connections, which allow the drum to rotate freely while they remain stationary to provide a solid connection to the steam pipe and condensate return system.

The embossing section consists of a 250 to 300 mm (10 to 12 in.) diameter, double-shelled embossing roll, which is designed to allow a cooling solution to pass through it in an efficient manner to remove heat as rapidly as possible, thereby setting in the embossing.

Embossing rolls typically have a double-shell design with a spiral wrap for the most efficient passage of the cooling medium.

For drums heated by hot oil, the construction is similar, but spiral windings forming passageways or channels are provided in the annular space between the inner and outer shells to allow the oil to flow in a prescribed path and in the most efficient manner, to promote good heat transfer. The hot oil is pumped through the center shaft of the drum and enters through conduits similar to the steam-heated drum design; after it has done its work, it leaves by similar passages at the opposite end of the drum. It is appropriate to pump the hot oil at rates that will cause it to flow in a turbulent manner through the drum annulus passageways, to provide the best heat transfer coefficient for optimal results.

The preheated web is stripped away from the main heating drum by use of the heated stripper rolls. These rolls help to maintain the temperature of the web and allow it to be passed into the embossing section. The stripper rolls are of single-shell construction and vary in size from 100 to 150 mm (4 to 6 in.) for steam-heated systems.

The infrared heater shown on the drop into the embossing section is used to maintain the ambient temperature around the web and to assure that the surface to be embossed will be entering the nip at approximately 160°C (320°F).

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The embossing roll design is also important because pressure is exerted between the embossing roll and the rubber-covered backup roll. The double-shell construction, along with the spiral winding, produces a roll that is structurally strong while still having excellent heat transfer capability.

The cooling solution is supplied to the roll through the use of rotary joints with rubber hoses; the solution goes in one end, flows through the spiraled annular construction of the roll, and is discharged at the other end.

Roll design becomes very important from the standpoint of heat transfer efficiency, and care must be taken to properly size the entrance and exit ports (to permit the required flow rate) and the annulus (to assure that the cooling solution is passing through it in the turbulent region of flow), thereby promoting the highest heat transfer coefficient and maximizing the cooling effect.

The backup roll is rubber covered and is cored for internal cooling, but primarily to keep the interface of the steel and rubber covering cool to avoid premature bond failure. The covering used on the roll should be abrasion resistant and able to withstand heat.

The two rolls are brought together hydraulically or pneumatically, with the embossing roll usually being the nondriven roll, while the backup roll is motor driven. To prevent stretching the product as it passes from one section to the other, it is important that synchronization between the main heating drum and the embossing section be accurately maintained.

It is important that the embossing roll be wrapped by the thermoplastic web. This enables cooling to take place while the web is still in intimate contact with the textured embossing roll.

Postcooling is more important on heavier gage materials, where residual heat in the web will later result in temperature rise in the rewound roll, causing a loss of embossing. In a sheet of this thickness, most of the cooling is achieved by the embossing roll and exit cooling roll. For the heavier sheets, it is recommended that dual-shell cooling rolls averaging 460 to 610 mm (18 to 24 in.) diameter and cooled through rotary joints be used to complete the cooling system.

42.3 Nonthermoplastic Embossing

Nonthermoplastic materials are embossed in a manner similar to the thermoplastic materials except that the force between the embossing roll and the backup roll is greater, so that the elastic limit of the material being deformed can be exceeded.

The predominant factor in embossing nonthermoplastic materials is the use of male and female rolls. This roll combination includes either metal male and female rolls, a metal embossing roll operating against a filled roll, or a metal embossing roll acting against a special compound, rubber-covered roll.

The use of metal male and female embossing rolls gives the most concise and definitive texture possible. The engraved patterns on both rolls are carefully matched to allow for insertion of the respective male parts into their counterparts.

The most commonly used combination of rolls is the metal embossing roll and the filled backup roll. This backup roll has either a saturated paper or a textile fabric composition, both of which are densely packed to form a very solid homogeneous structure. The roll is then finished to a specific diameter and when placed in the embossing machine is usually "run in" by bringing the metal embossing roll into contact with the filled roll under load. By continually running the two rolls in contact with each other, the embossing roll pattern is imparted to the surface of the backup roll, giving a male–female characteristic without the use of two mating metal rolls. This combination is excellent for thin as well as heavier materials, as embossing roll–backup roll contact is inconsequential with one metal roll and a composition backup roll.

The use of a rubber-covered backup roll for nonthermoplastic materials depends strictly on the embossing load. There are certain rubber compositions, such as cast urethanes, which will act similar to a composition roll. They do not require "running in" but will deform under the load of the embossing roll.

The backup rolls for nonthermoplastic materials have a much larger diameter than those used for the thermoplastic webs. This is due to embossing loads and wear. The larger surface gives less revolution of the roll and, hence, less wear of the surface as compared to a similar roll. The larger diameter gives a better structural member to resist deflection.

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